Universal Quantum Emulator

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Abstract

In this talk I present a new quantum algorithm that emulates the action of an unknown unitary transformation (or its inverse) on a given input state, using multiple copies of some unknown sample input states of the unitary and their corresponding output states. The algorithm does not assume any prior information about the unitary to be emulated, or the sample input states. To emulate the action of the unknown unitary, the new input state is coupled to the given sample input-output pairs in a coherent fashion. Remarkably, the runtime of the algorithm is logarithmic in D, the dimension of the Hilbert space, and increases polynomially with d, the dimension of the subspace spanned by the sample input states. Furthermore, the sample complexity of the algorithm, i.e. the total number of copies of the sample input-output pairs needed to run the algorithm, is independent of D, and polynomial in d. In contrast, the runtime and the sample complexity of incoherent methods, i.e. methods that use tomography, are both linear in D. The algorithm is blind, in the sense that at the end it does not learn anything about the given samples, or the emulated unitary. This algorithm can be used as a subroutine in other algorithms, such as quantum phase estimation.